REPORT

Contact person
Christian Larsson
Building Technology and Mechanics
+46 10 516 57 61
Christian.Larsson@sp.se

Flagmore AB
Box 16
522 21 TIDAHOLM

Test of flagpole

1 Introduction

By commission of Flagmore AB a bending test of a flagpole was performed.

Test place: Flagmore test site in Tidaholm, Sweden.

2 Test object

Designation: Flagpole "9m Nordic" made of glass-fibre reinforced polyester.

Height	9 m
Diameter at base	120 mm
Diameter at top	65 mm

Selection of test objects: The test objects have been selected by the client without SP's assistance.

3 Test method and implement

Test method: The flagpole was tested with a force attached perpendicular to the top. The force was increased until rupture occurred. The force was measured with a load cell connected to a computer with the sampling rate of 1000 Hz. After the test a calculation of the bending moment in the bottom part of the flagpole was performed. An equally, over the whole length of the flagpole, distributed force giving the same bending moment at the bottom of the pole was then calculated. This equally distributed force was translated to a wind speed. The calculations are presented in the test results.

Measurements: Maximum load was registered.

Test date: 20 September, 2011.

4 Test results

The flagpole broke in 6 pieces at a force at the top of **613 N**. The orientation of the ruptures were 1.2 m, 2.1 m, 2.9 m, 3.7 m and 5.4 m from the base and the top of the pole was when it broke bent approximately 4.8 m.

Following calculations are performed in accordance with the Swedish Building requirement for calculation of wind load.

Calculation of bending moment generated from a force attached to the top of the pole.

h = Height of pole, m.
F_h = Breaking force N.

$$\mathbf{M_v = F_h \times h} = 613 \times 9 = \mathbf{5517\ Nm}$$

Calculation of an equally distributed force generating same bending moment at the base of the pole.

d_b = Diameter at base of pole, m.
d_h = Diameter at top of pole, m.
L = Distance from base to the projected centre of area.

$$L = \frac{h\,(d_b + 2d_h)}{3(d_b + d_h)} = \frac{9\,(0.120 + 2 \times 0.065)}{3\,(0.120 + 0.065)} = \mathbf{4.05\ m}$$

$$F = \frac{M_v}{L} = \frac{5\,517}{4.05} = \mathbf{1361\ N}$$

Calculation of wind pressure

φ = Density of air at ambient temperature, kg/ m^3 = 1.25 kg/ m^3
v = Wind speed, m/s
F = Force equally distributed over the projected area, 1361 N.
C_f = Factor cylindrical shape = 1.2.
A = Projected area, = $\frac{d_b + d_h}{2} \times h$, m^2
q = Wind pressure, N/ m^2.

$$\mathbf{F = C_f \times q \times A}$$

$$\mathbf{q} = \frac{\mathbf{F}}{\mathbf{C_f \times A}} = \frac{2 \times 1361}{1.2 \times 9\,(0.065 + 0.120)} = \mathbf{1362\ N/\ m^2}$$

Calculation of wind speed

$$\mathbf{q = 0.5 \times \varphi \times v^2}$$

$$v^2 = \frac{q}{0.5 \times 1.25} = \frac{1362}{0.5 \times 1.25} = 2209$$

$$v = 47 \text{ m/s}$$

The breaking force of the flagpole corresponds approximately to a maximum wind speed of **47 m/s**. Effects from flag and flag-line are considered being minor and are not taken into consideration in the calculations. The fact that the flagpole is bending because of the wind pressure and the projected area because of this is becoming lesser is also not taken into consideration.

5 Measurement uncertainty

The total calculated measurement uncertainty for the maximum load is < 1 %. Reported uncertainty corresponds to an approximate 95 % confidence interval around the measured value. The interval has been calculated in accordance with GUM (The ISO guide to the expression of uncertainty in measurements), which is normally accomplished by quadratic addition of the actual standard uncertainties and multiplication of the resulting combined standard uncertainty by the coverage factor k=2.

SP Technical Research Institute of Sweden
Building Technology and Mechanics - Solid Mechanics and Structures

Performed by

Christian Larsson

Examined by

Lars Andersson